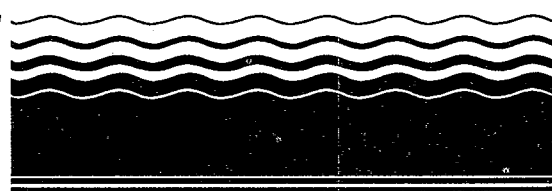




# **SITE**

**SUPERFUND INNOVATIVE  
TECHNOLOGY EVALUATION**



## **Technology Demonstration Summary**

### **Technology Evaluation Report; SITE Program Demonstration Test; Retech, Inc. Plasma Centrifugal Furnace; Butte, MT**

A demonstration of the Retech, Inc. pilot-scale Plasma Centrifugal Furnace (PCF-6) has been performed under the Superfund Innovative Technology (SITE) Program. The demonstration occurred in July 1991 at the U.S. Department of Energy's (DOE's) Component Development and Integration Facility (CDIF) in Butte, MT. The PCF is designed to treat hazardous material contaminated with both inorganic (metal) and organic constituents by using the heat generated from a plasma torch to melt metal-bearing solids and, in the process, thermally destroying organic contaminants.

During the Demonstration Tests, the PCF-6 treated a waste matrix consisting of soil from the Silver Bow Creek Superfund Site and 10% by weight No. 2 diesel oil. The Demonstration Test results indicate that the PCF can bind inorganic compounds into the treated soil (a nonleachable monolith). Testing activities also demonstrated that the process can effectively destroy the organic compounds tested, achieving at least a 99.99% Destruction and Removal Efficiency (DRE).

The air emissions generated during the Demonstration Tests contained only low levels of volatile and semivolatile organic compounds. However, metals (in the solid phase) were present in abundance in the stack gas and the particulate emissions during each of the three tests exceeded the RCRA regulatory limit of 0.08 grains/dscf.

The post-test scrubber liquor did not contain any significant quantities of organic compounds. The lack of organic compounds in the scrubber liquor and, as stated above, the absence of volatiles or semivolatiles in the exhaust gas, indicates that combustion of the organic compounds was complete. The scrubbing unit was very inefficient in the capture of particulates and inorganic compounds.

The cost of this remediation technology is high because of the capital cost of the equipment and the labor requirements. The cost per ton for this technology is very dependent on the feed rate of the contaminant to the furnace.

*This summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the SITE Program dem-*



onstration that is fully documented in two separate reports (see ordering information at back).

## Introduction

In response to the Superfund Amendments and Reauthorization Act of 1986 (SARA), the U.S. Environmental Protection Agency's (EPA's) Offices of Research and Development (ORD) and Solid Waste and Emergency Response (OSWER) have established a formal program to accelerate the development, demonstration, and use of new or innovative technologies as alternatives to current containment systems for hazardous wastes. This new program is called Superfund Innovative Technology Evaluation or SITE.

The major objective of the SITE Program is to develop reliable performance and cost information for innovative technologies. One technology, which was demonstrated in July 1991 at DOE's CDIF in Butte, MT, was the Retech, Inc. Plasma Centrifugal Furnace. The Retech system is comprised of a thermal treatment system and an exhaust gas treatment system, shown conceptually in Figure 1. The PCF uses heat generated from a plasma torch to melt and vitrify solid feed material. Metal-bearing solids are bound into a monolithic nonleachable mass. Organic components are vaporized and decomposed by the intense heat of the plasma and are oxidized by the air used as the plasma gas,

before passing to the off-gas treatment system.

The waste matrix utilized during this demonstration was a mixture of heavy metal-bearing soil and diesel oil spiked with both a metal and an organic compound to ensure traceability. Three Demonstration Tests were performed to evaluate the effectiveness of the Plasma Centrifugal Furnace in treating this waste matrix and to evaluate the feasibility of employing similar units at hazardous waste treatment facilities throughout the country. To facilitate this evaluation, the following objectives were established:

- To evaluate the ability of the furnace to effectively vitrify inorganic and metal constituents within a soil into a monolithic nonleachable mass. (Zinc oxide was spiked into the soil at a level of 28,000 ppm.)
- To evaluate the ability of the Plasma Centrifugal Furnace to meet 99.99% destruction and removal efficiency (DRE) for the target analytes in a soil contaminated with up to 10% organics. (Hexachlorobenzene was spiked into the feed soil at 1,000 ppm so that a DRE of 99.99% could be easily calculated. DREs for other target analytes were determined if these compounds were present at high enough levels in the feed soil.)

Specific critical and noncritical objectives may be found in the Demonstration

Plan [1]. In addition to allowing an evaluation of the technology for potential Superfund applications, the activities and results of this testing will also provide assistance to DOE in their evaluation of the technology for the remediation of hazardous waste sites under their jurisdiction.

## Procedure

A total of 1,440 lb of the spiked soil were treated during the three Demonstration Tests. For each test, samples of the feed soil, the treated soil, the scrubber liquor, and the stack emissions were collected to evaluate the performance of the technology. Samples were collected and analyzed in accordance with the Demonstration Plan with only minor changes in some of the sampling and analytical methods. Analyses included volatile and semivolatile organic compounds, dioxins/furans, metals, and particulate matter. Both the test soil and the treated soil were subjected to the Toxicity Characteristic Leaching Procedure (TCLP) and analyzed for semivolatiles and metals.

Process operations were continuously observed by operators and their supervisors. Process measurements were recorded manually or electronically by the data acquisition system (DAS). Important process information was also calculated by the DAS.

To aid in striking the arc, approximately 100 lb of mild steel in the form of a 1-in.

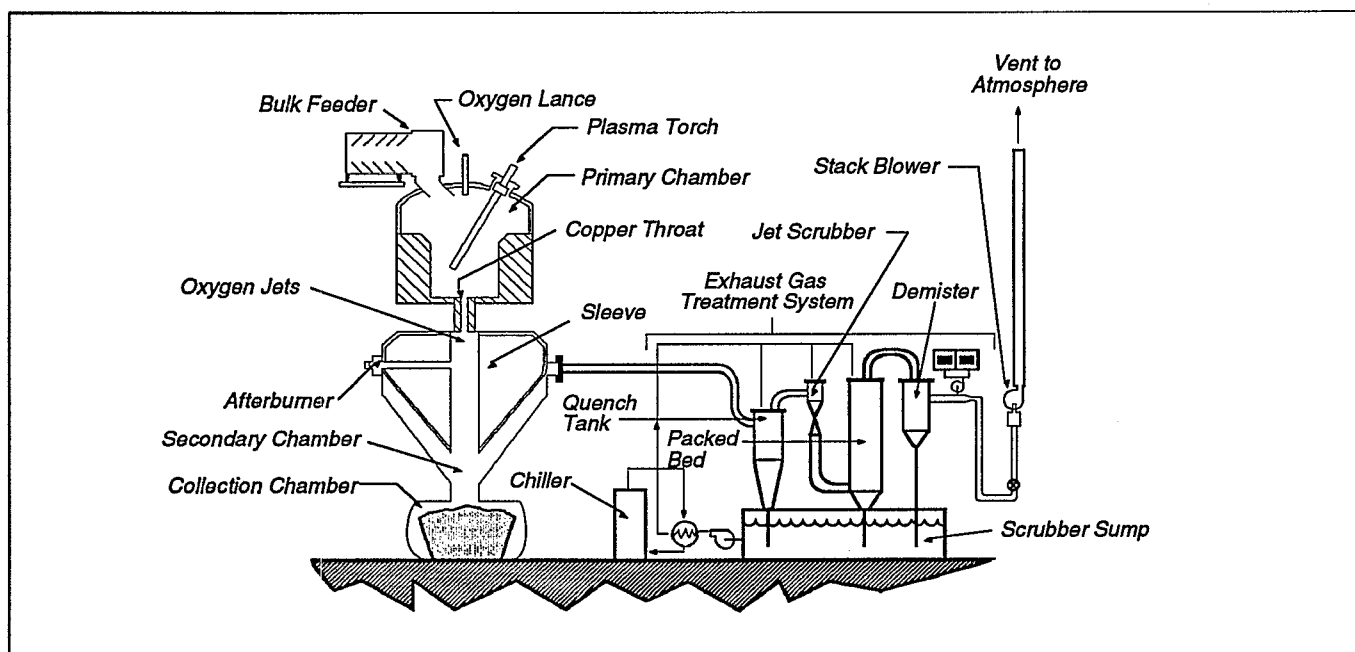


Figure 1. Conceptual Design of Plasma Centrifugal Furnace.

thick "doughnut" were placed inside the primary combustion chamber. The torch was struck after a final check of the process equipment. Before material could be fed into the furnace, operating procedures require that the primary chamber temperature must be at least 2,100 °F and the afterburner temperature 1,800 °F. Three to five hours of operating time were necessary to achieve these temperatures.

The torch arc was struck on the copper throat or the mild steel doughnut, both centrally located at the bottom of the spinning furnace. This area was the first location to be preheated. After the material adjacent to the copper throat was heated to the conducting temperature, the torch was moved slowly to heat and melt more of the soil of the bottom of the furnace and eventually the sidewall. This was continued until the entire contents of the primary chamber were melted by the torch.

Following the preheat period, the test soil was fed into the furnace in a semi-batch manner. Approximately 120 lb of the soil were manually loaded into the feeder at a time and fed into the furnace at a uniform rate. Once fed into the furnace, treatment of the waste material with the plasma torch was initiated. It took approximately one hour to melt each feeder load. After each feeder load was melted, the feeding process was repeated until a maximum of 1,000 lb were fed to the furnace.

The waste material was brought to temperatures sufficient to melt soil. The melting point for typical soil is on the order of 3,000 °F. Volatile components were vaporized and decomposed by the heat of the plasma, and were oxidized by the air used as the plasma gas. To combust any products of incomplete combustion (PICs) that were formed, a natural gas afterburner was employed just downstream of the primary chamber.

After the last desired charge was melted, the afterburner was extinguished, the furnace spin rate was slowed to allow the molten pool to move inward and the melted soil to pour out of the bottom of the furnace, into the secondary chamber. The organics that were volatilized and oxidized were drawn off to the exhaust gas treatment system.

The molten mass fell from the secondary chamber, through the collection chamber, and into a heavy pig mold. The pouring process took 5 to 10 min for a 600-lb pig. The molten mass solidified into a hard monolith which was then disposed of in an appropriate landfill or otherwise utilized.

## Results and Discussion

TCLP analysis of the feed soil for metals showed that the only elements which exhibited significant leachability characteristics were calcium, sodium, and the spiked zinc. Table 1 summarizes the results of the TCLP metals analysis of the feed soil. None of the eight RCRA characteristic metals found in the feed soil leachate were above their regulatory limits, therefore, the evaluation of the leachability of the vitrified slag was based on calcium, which leached at an estimated average of 180 ppm, and zinc, which leached at an estimated average of 980 ppm. (Sodium was not used because of its unusual solubility properties.)

The treated soil TCLP metals analysis is also shown in Table 1. None of the metals, with the exception of sodium, showed any strong characteristic for leaching. Both tracer metals, calcium and zinc, showed significant reductions in leaching properties in the treated soil as compared to the feed. In fact, all of the metals, with the exception of aluminum and iron showed reduced leaching characteristics. It is quite possible that the leachability for the aluminum did not change since the values obtained for both the test soil and the treated soil are only estimates (see Table 1). The increase in leachability of iron in the treated soil was probably because of the mild steel placed in the furnace to aid in initiating the striking of the torch arc.

The only organic constituents that were found to be leachable from the feed soil were 2-methylnaphthalene and naphthalene, as shown in Table 1. Although the feed soil was spiked with high levels of hexachlorobenzene (1,000 ppm), it did not leach from the soil. No organic compounds were found to leach from the treated slag.

The Destruction and Removal Efficiency (DRE), used to determine organic destruction, was determined by analyzing for the Principal Organic Hazardous Compound (POHC), hexachlorobenzene, in the feed soil and the stack gas. No hexachlorobenzene was detected in the stack gas, therefore, all DREs determined are based on the detection limit from the appropriate tests. Table 2 gives these DREs based on the 95% confidence interval of the feed soil and the detection limit for the POHC in the stack gas for each test.

As can be seen from Table 2, the estimated average DRE values for these tests ranged from >99.9968% to >99.9999% for a highly chlorinated compound (hexachlorobenzene). It can be reasonably assumed that this level of DRE (if measurable) can be achieved for most chlorinated or halogenated compounds.

Analysis of the feed soil indicated that sufficient 2-methylnaphthalene, another semivolatile compound, was present at high enough levels in the feed to determine a significant DRE for each test. This level of contamination in the feed soil leads to the DREs given in Table 2, again based

Table 1. TCLP Results for Demonstration Tests

Compound	Average Feed Soil Leachate Concentration (mg/L)	Treated Soil Leachate Concentration		
		Test 1 (mg/L)	Test 2 (mg/L)	Test 3 (mg/L)
Metals:				
Aluminum	0.23 J	0.45 J	0.42 J	0.32 J
Barium	0.14	0.078	0.085	0.075
Cadmium	0.067	<0.039	<0.039	<0.039
Calcium	180	2.1 J	2.6 J	2.0 J
Copper	4.6	0.15	0.36	0.30
Iron	0.063	2.5	3.0	31.2
Magnesium	8.1	<0.039	<0.039	<0.039
Manganese	4.8	0.057	0.061	0.24
Nickel	0.022	<0.011	0.010 J	0.11
Potassium	4.6	<0.70	<0.70	<0.70
Sodium	1,500	1,500	1,400	1,400
Vanadium	0.099	<0.0043	<0.043	<0.043
Zinc	980	0.45	0.36	0.3
Semivolatiles:				
Hexachlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010
2-Methylnapthalene	0.28	<0.0019	<0.0019	<0.0019
Napthalene	0.40	<0.0026	<0.0026	<0.0026

J Estimated result. Indicates that the result is less than the quantitation limit. The quantitation limit is defined as 5 times the instrument detection limit.

< Indicates that this constituent was not detected at or above the detection limit.

**Table 2. DRE Results for Demonstration Tests**

Compound	Test 1	Test 1 Duplicate	Test 2	Test 3
<b>Hexachlorobenzene</b>				
Lower 95% Conf.Int.	>99.9964	>99.9982	>99.9990	>99.99989
Mean	>99.9968	>99.9984	>99.9991	>99.99990
Upper 95% Conf. Int.	>99.9971	>99.9986	>99.9992	>99.99991
<b>2-Methylnaphthalene</b>				
Lower 95% Conf.Int.	>99.9853	>99.9930	>99.9958	>99.99960
Mean	>99.9872	>99.9939	>99.9964	>99.99965
Upper 95% Conf.Int.	>99.9891	>99.9948	>99.9969	>99.99970

on detection limits, as none of this compound was detected in the stack gas.

Total xylenes, a group of volatile compounds, were also found in sufficient quantities in the feed soil to determine a significant DRE. Over all three tests, the DRE range for xylenes was >99.9929% to >99.9934%. These DREs are an average over all three tests based on the 95% confidence interval of xylenes in the feed soil and the detection limit for xylenes in the stack gas.

Overall, the PCF-6 appeared to be very efficient in destroying both volatile and semivolatile compounds when both the primary reaction chamber and the afterburner were operating.

Measured HCl emission rates ranged from 0.0007 to 0.0017 lb/hr. Because of the low chlorine input, the regulatory requirement of <4 lb/hr was met.

As shown in Table 3, the particulate emissions during each of the three tests exceeded the RCRA regulatory limit of 0.08 grains/dscf. Hazardous waste incinerators operating under conditions of oxygen enrichment (such as the Retech PCF) are exempt from the RCRA requirement to correct emissions to 7% O<sub>2</sub>. Therefore, these emission rates have not been corrected to 7% oxygen. If the correction was to be applied only during the feeding cycle (when presumably the particulates were being generated) then the values given in Table 3 should be increased by a factor of 1.4.

**Table 3. Particulate Results for Demonstration Tests**

	Test 1	Test 1 Duplicate	Test 2	Test 3
<b>Particulate Concentration (grains/dscf)</b>	0.341	0.240	0.422	0.410
<b>Particulate Emissions (lb/hr)</b>	0.342	0.238	0.418	0.423

The air emissions consisted primarily of particulates and low levels of products of incomplete combustion (PICs). Table 4 presents a summary of the semivolatile organic compounds emitted in the stack gas. Very low levels of volatile organic compounds were also detected in the exhaust gas stream.

Sampling and analysis for polychlorodibenzodioxins (PCDDs) and polychlorodibenzofurans (PCDFs) in the exhaust gas stream were accomplished during the Demonstration Tests. The results of these analyses indicate that no PCDDs or PCDFs were formed in the stack gas. Although some PCDDs and PCDFs were detected in some of the samples analyzed, the levels detected were less than the corresponding blank sample detection limit.

Metal emissions were almost exclusively in the solid phase. Table 4 summarizes these results. The only significant vapor phase metals found were calcium and mercury. A very volatile metal such as mercury is expected to be found in the vapor phase. Arsenic, copper, iron, lead, potassium, and zinc were in abundance in the stack gas in the solid phase. It appears that not all of the volatile metals were captured in the molten soil at the completion of treatment. If this is the case, then these volatile metals should have been captured by the gas treatment system (assuming it is correctly designed).

Analysis of the feed soil showed that it contained volatile compounds consistent with those associated with diesel fuel: benzene, toluene, ethyl benzene, and xylene (BTEX). These compounds were detected in the quantities presented in Table 5. The semivolatile compounds found most predominantly in the feed soil were the spiked hexachlorobenzene and 2-methylnaphthalene (see Table 5). As shown in Table 6, the metals found most abundantly in the feed soil were aluminum, calcium, iron, potassium, sodium, and zinc.

Volatile organic analysis was not performed on the treated soil as no volatile compounds were considered to exist in

the slag after it had reached its melting point temperature. The only semivolatile organic compounds found in the treated soil were low levels of two phthalate compounds which were probably sampling or analytical contaminants. This agrees with the TCLP analysis of the slag discussed earlier in which no semivolatile compounds leached from the slag.

A mass balance that yields meaningful results cannot be performed on this technology since a portion of material from each test can possibly remain in the furnace at the end of treatment. It is possible, though to compare the concentration of the inorganic elements in the feed soil with that of the collected slag, taking into account the destruction of the 10% organics and assuming that none of the elements are concentrated in the poured slag. Table 6 gives the concentrations of the metals in feed and in the slag for all three of the tests. The feed is an average of all feed samples from the three tests. This table shows that a large percentage of the metals from the feed soil are retained within the vitrified slag. For example, for Test 3, 88% of the aluminum originally present in the feed soil was detected in the treated soil. Exceptions to this trend are generally the volatile metals: arsenic, lead, mercury, and zinc. During Test 3, only 38% of the zinc from the feed soil was retained in the treated soil. These volatile metals have been found, as stated earlier, to be exiting the system through the exhaust stack or plating out on the walls of the extensive exhaust system. In addition, some of these metals can be found in the scrubber liquor.

Only the treated soil (not the feed soil) was analyzed for PCDDs and PCDFs during the Demonstration Tests. The levels of PCDDs and PCDFs in the treated soil were very low. However, as described earlier for stack gas emissions, the detection limits for blank samples are higher than the amount of PCDDs and PCDFs detected in the samples. It is therefore reasonable to conclude that no PCDDs or PCDFs were formed by the treatment process, and if any dioxins/furans were in the feed, they were destroyed by the intense heat of the process.

The pre-test scrubber liquor for each of the three Demonstration Tests contained very little in the way of organic compounds. A metals scan on the pre-test scrubber liquor showed that, generally, only low levels of inorganic elements were present. The post-test scrubber liquor did not contain any significant quantities of organic compounds. The lack of organic compounds in the scrubber liquor and, as

**Table 4. Stack Gas Composition During Demonstration Tests**

	Test 1		Test 2		Test 3	
	lb/100 lb feed	ppm	lb/100 lb feed	ppm	lb/100 lb feed	ppm
<b>Semivolatiles:</b>						
Acetophenone	<2.15E-06	<0.38	4.63E-06	J 0.71	J 2.30E-06	0.031
Benzoic Acid	3.77E-04	6.7	3.29E-04	4.9	1.98E-04	2.6
Benzyl Alcohol	<4.95E-07	<0.0099	<1.65E-07	<0.0033	3.76E-07	J 0.0056
Butylbenzylphthalate	<3.28E-07	<0.0023	<1.09E-07	<0.00079	3.76E-07	J 0.0056
Dibutylphthalate	<9.93E-07	B <0.0077	4.48E-06	JB 0.030	1.15E-06	B 0.0067
Diethylphthalate	<5.41E-05	B <0.70	2.54E-05	B 0.28	2.50E-05	B 0.24
2,4-Dinitrophenol	2.13E-05	J 0.25	1.27E-05	J 0.13	5.74E-06	0.050
bis(2-Ethylhexyl)phthalate	7.36E-05	B 0.41	5.08E-05	B 0.24	4.69E-06	B 0.019
Naphthalene	1.68E-05	B 0.26	8.96E-06	B 0.12	1.15E-05	B 0.134
Nitrobenzene	<3.13E-07	J <0.0055	2.84E-06	J 0.042	1.56E-06	0.021
2-Nitrophenol	<8.56E-06	J <0.13	2.09E-06	J 0.028	1.36E-05	0.16
4-Nitrophenol	1.15E-05	J 0.18	<1.43E-05	<0.22	1.01E-05	0.12
<b>Metals:</b>						
Aluminum	5.02E-04	B 1.34	9.56E-04	B 2.10	5.67E-04	B 1.14
Antimony	1.18E-05	0.031	4.16E-05	0.091	2.62E-05	0.053
Arsenic	1.88E-03	B 5.02	2.98E-03	B 6.54	2.47E-03	B 4.97
Barium	4.26E-05	B 0.114	8.09E-05	B 0.177	6.11E-05	B 0.123
Beryllium	1.63E-07	0.001	3.58E-07	0.001	2.91E-07	0.001
Cadmium	1.76E-05	0.047	3.99E-05	0.088	2.76E-05	0.056
Calcium	8.41E-04	B 2.51	1.74E-03	B 3.81	9.60E-04	B 1.93
Chromium	3.39E-04	B 0.904	6.57E-04	B 1.44	7.27E-04	B 1.46
Copper	1.63E-03	B 4.35	4.71E-03	B 10.3	2.04E-03	B 4.09
Iron	1.51E-02	B 40.2	3.01E-02	B 66.1	4.51E-02	B 90.6
Lead	9.28E-04	B 2.48	2.29E-03	B 5.02	1.60E-03	B 3.21
Magnesium	2.01E-04	B 0.535	3.26E-04	B 0.716	2.47E-04	B 0.497
Manganese	1.14E-04	B 0.305	2.48E-04	B 0.544	3.20E-04	B 0.643
Mercury	1.38E-06	B 0.004	2.92E-06	B 0.006	5.09E-06	B 0.010
Nickel	6.65E-05	B 0.177	1.10E-04	B 0.372	1.74E-04	B 0.351
Potassium	3.76E-03	10.0	7.11E-03	15.6	6.69E-03	13.4
Selenium	5.02E-06	0.013	1.11E-05	0.024	6.40E-06	0.013
Silver	2.88E-06	0.008	6.32E-06	0.014	4.65E-06	0.009
Sodium	2.26E-03	B 6.02	4.26E-03	B 9.35	3.78E-03	B 7.56
Thallium	5.52E-06	0.015	1.35E-05	0.030	1.25E-05	0.025
Vanadium	2.76E-05	0.074	6.57E-05	0.144	4.51E-05	0.091
Zinc	3.01E-02	80.3	8.36E-02	B 183	5.53E-02	B 111

B Indicates that this compound was detected in a blank.

J Estimated result. Indicates that result is less than the quantitation limit. Quantitation limit is five times the instrument detection limit.

< Not detected at or above the detection limit.

stated earlier, the absence of volatile or semivolatiles organic compounds in the exhaust gas, indicates that combustion of the organic compounds was complete.

The scrubbing unit was very inefficient in the capture of the inorganic compounds. There was less than 0.5% total solids in the scrubber sump tank. The scrubber did capture some of the volatile metal elements but not at the levels that would typically be expected from a well-designed system. As stated previously, the exhaust gas contained a variety of metals that should have been captured by the scrubbing unit. The types of metals found in the scrubber liquor were similar to those found in the stack gas; that is, arsenic, iron, and zinc were the elements in abundance. High sodium levels found in the liquor were a consequence of the scrubber make-up (sodium hydroxide).

Throughout each of the three tests, CO, CO<sub>2</sub>, O<sub>2</sub>, NO<sub>x</sub>, and Total Hydrocarbons (THC) were monitored continuously to present a real time image of the combustion process and to determine if regulatory standards were being exceeded. The low flowrate of the stack gas (110 scfm) prevented these emissions from approaching regulatory limits. During the Demonstration Tests, the THC exiting the system was low (<4 ppm), even with 10%, or more, organics in the feed. The exhaust gas contained low levels of CO (approximately 1.4 ppm) and a level of approximately 8% CO<sub>2</sub>. These levels of THC, CO, and CO<sub>2</sub> gave a good indication that effective thermal destruction of the organic compounds occurred. However, the levels of NO<sub>x</sub> were consistently high throughout each of the three tests.

**Table 5. Organic Compounds in the Demonstration Test Soil**

Compound	lb/100 lb feed	ppm
<b>Volatiles*:</b>		
Benzene	9.91E-05	0.991
Ethyl Benzene	2.84E-03	28.4
Toluene	1.81E-03	18.1
Xylene	1.34E-02	134
<b>Semivolatiles**:</b>		
Hexachlorobenzene	9.72E-05	972
2-Methylnaphthalene	4.58E-05	458
Naphthalene	1.52E-02	150
Phenanthrene	6.62E-03	66.2

\* 1,2-Dichloroethane and methyl ethyl ketone were both detected in a few samples, but only at low levels.

\*\* Other compounds were detected in a few samples, but only at low levels.

**Table 6. Metals in the Demonstration Test Feed Soil and Treated Soil**

Element	Average Feed Soil (ppm)		Treated Soil				
			Test 1 (ppm)		Test 2 (ppm)		Test 3 (ppm)
Aluminum	49,400	B	51,200		46,000		43,700
Arsenic	201		12.0	J	16.0	J	11.3
Barium	508		523		480		453
Calcium	12,500		28,800		20,500		18,000
Chromium	23.6	J	500		510		617
Copper	591		780		1,500		827
Iron	36,900	B	160,000		150,000		213,333
Lead	426		98.3	J	115	J	120
Magnesium	4,650		5,720		4,600		4,670
Manganese	814		1,850		1,900		2,570
Mercury	1.00		<0.133		<0.133		<0.133
Nickel	NA		270		265		287
Potassium	19,360		15,500		16,000		14,700
Sodium	10,200		8,180	B	8,650		7,830
Vanadium	77.3	J	59.8	J	159.5	J	50.0
Zinc	23,200		6,480		9,050		8,800

B indicates that this compound was detected in a blank

J = Estimated result. Indicates that the result is less than the quantitation limit. The quantitation limit is defined as 5 times the instrument detection limit.

NA = Not analyzed

Since all three Demonstration Tests were designed to be identical in nature, operating conditions during the tests were relatively constant. Although the mass of material to be fed during each test was anticipated to be 960 lb, the actual weight of the feed was 480, 360, and 600 lb for Tests 1, 2, and 3, respectively. The corresponding weight of the treated soil generated during the tests was 277, 265, and 595 lb.

The torch power ranged from an average of approximately 410 kW during Test 3 to nearly 460 kW during Tests 1 and 2. The total power consumption of the torch ranged from 3,308 kWh (Test 1) to 4,720 kWh (Test 3). The torch gas in each case was air with a flowrate of 23 to 24 scfm. Excess oxygen was supplied from an oxygen lance at a rate of approximately 1 lb/min.

The reactor chamber temperature, once it stabilized, achieved an average value of approximately 2,250 °F. The afterburner temperature averaged around 1,800 °F (slightly higher during Test 3) once the system reached operating range.

The scrubber liquor generated during each of Tests 1 and 2 was close to 150 gal. During Test 3, this value was greatly exceeded due to frequent blowdowns of the scrubber in an attempt to reduce particulate loading on the blower downstream. Nearly 800 gal of scrubber liquor were generated during Test 3.

## Conclusions

Based on the Demonstration Tests, a number of conclusions regarding the Retech Plasma Centrifugal Furnace may be drawn. The conclusions are presented below:

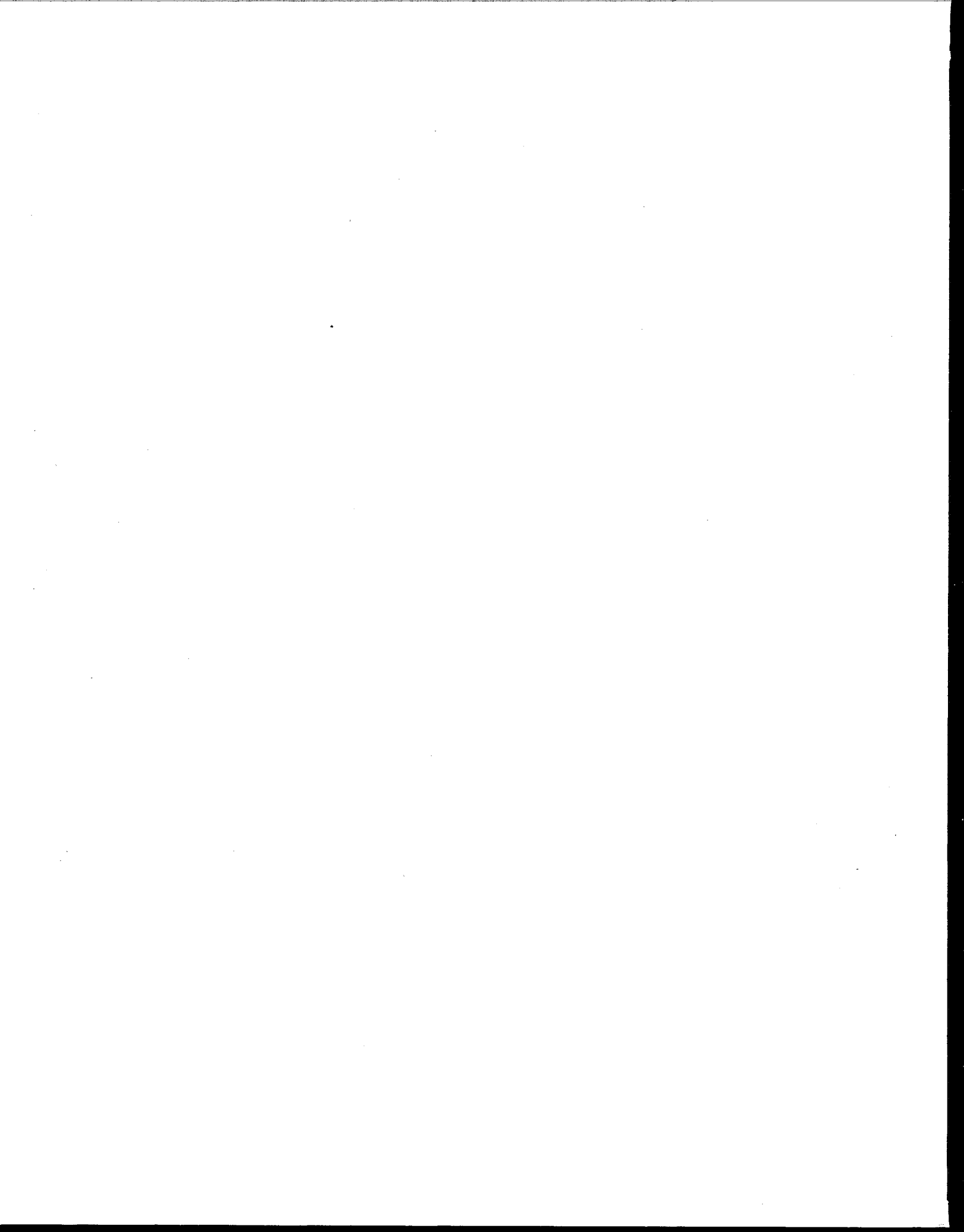
- The PCF is an innovative technology used to process media contaminated with both organic and inorganic regulated compounds which became non-leachable after treatment.
- The Destruction and Removal Efficiency (DRE) of organic compounds tested was greater than 99.99%.
- Particulate emissions from the treatment process used during the

Demonstration Tests exceeded the RCRA regulatory limit of 0.08 grains/dscf.

- NO<sub>x</sub> concentrations in the stack gas were high, averaging 4,800 ppm (uncorrected to 7% oxygen); however, emission rates were within regulatory limits because of the low flowrates.
- A high percentage of the metals from the feed soil were captured and retained in the vitreous slag. A proportion of the more volatile metals evolved from the feed and passed through the furnace and the gas scrubbing system.
- The scrubber was not effective in capturing the volatile metal elements.
- The PCF-6 is not mobile. Retech estimates that approximately 2 mo are required to install, erect, and shakedown all equipment prior to operation of the system.
- The furnace, as configured, must be erected within an enclosed facility. Onsite requirements include adequate power supply, cooling water, and cranes for lifting.
- The Plasma Centrifugal Furnace was effective for treating soils contaminated with both metal and organic compounds. However, the projected cost of this remediation technology is high because of the capital cost of the equipment and the labor requirements. The cost per ton for this technology is very dependent on the feed rate of the contaminant to the furnace. For a feed rate of 500 lb/hr and an on-line factor of 70%, the cost is \$1,816/ton; for 2,200 lb/hr (70% on-line factor) the cost becomes \$757/ton.

## References

1. Science Applications International Corporation. July 11, 1991. "Demonstration Plan for Centrifugal Plasma Furnace Technology."



*The EPA Project Manager, Laurel J. Staley, is with the Risk Reduction Engineering Laboratory, Cincinnati, OH 45268 (see below)*

*The complete report, entitled "Technology Evaluation Report of Retech's Plasma Centrifugal Furnace," consists of two volumes:*

*"Volume I" (Order No. PB92-216 035-V1; Cost: \$26.00, subject to change) discusses the results of the demonstration.*

*"Volume II", (Order No. PB92-216 043-V2; Cost: \$43.00, subject to change) contains the appendices.*

*Both volumes of this report will be available only from:*

*National Technical Information Service*

*5285 Port Royal Road*

*Springfield, VA 22161*

*Telephone: 703-487-4650*

*A related report, entitled "Applications Analysis Report: Retech, Inc., Plasma Centrifugal Furnace," discusses the applications of the demonstrated technology.*

*The EPA Project Manager can be contacted at:*

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